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the AEROVOX Research Worker

The Aerovox Research Worker is a monthly house organ of the Aerovox Corporation. It is published to bring to the Radio Experimenter and Engineer authoritative, first hand information on condensers and resistances for radio work.

VOL. 14 NOS. 11 & 12 NOVEMBER-DECEMBER, 1942 50c per year in U.S.A. 60c per year in Canada

Design Data for *m*-Derived Type Filters

PART II

By the Engineering Department, Aerovox Corporation

INDUCTANCE and capacitance values given in the tables appearing in this issue are for low- and high-pass series- and shunt-derived filters of 500 ohms and 10,000 ohms characteristic impedance. Constants for band-pass and band-suppression sections will be given in the next issue.

The inductance and capacitance values for each type appear directly opposite the corresponding cut-off frequencies which are listed in the first column. No calculations are necessary if the tables are employed directly, except when single sections are to be combined for sharper cut-off, as will be explained in a succeeding issue.

Except where otherwise noted in the tables, frequencies are stated in cycles per second, inductances in henries, and capacitances in microfarads. If it is necessary to employ a characteristic impedance (R) other than the values for which components are listed, the designer must first locate in the table components for a 500-ohm filter. The inductance value for the new impedance will then be obtained by multiplying the listed L value by R/500, and the capacitance value for the new impedance by dividing the listed C value by R/500.

PRECAUTIONS IN FILTER DESIGN

Components selected for use in *m*-derived filter sections must be of good quality to insure efficient operation. The d.c. resistance of all coils, for example, must be low and the Q of all coils and capacitors as high as practicable for the operating frequency, for best results. Excellence of filter action will depend upon the efficiency of the parts employed and the accuracy of their values.

Coils for use at commercial power frequencies and low audio frequencies may be of good iron-core construction, while those intended for filters which will operate at the higher audio frequencies should have powdered-iron cores. Filter coils for use at radio frequencies should be universal-wound, preferably with Litz wire, in order to minimize distributed capacitance and, when the operating frequency permits, should be provided with powdered-iron cores and rings for improvement of Q. Appropriate shielding of individual components from each other and shielding of the entire filter unit is good practice.

In filter sections where capacitance is shown connected in parallel with inductance, the distributed capacitance of the coil may be figured into the total shunting capacitance given by the C values in the tables. In all other cases, every expedient must be taken to keep the distributed capacitance of inductive arms low in order to prevent undesired shunting effects.

Inductance and capacitance of *m*-derived filter elements must be accurately maintained. The capacitor arms, more so than the coil arms, lend themselves to close final adjustment by means of paralleled units. In radio-frequency units, where capacitances required are generally small enough to permit the use of variable or partially-variable units, at least a portion of the total capacitance of any arm might be a trimmer condenser for accurate final setting of the arm. Likewise, at certain frequencies it is possible to obtain inductive trimming in a coil arm by varying the length of powdered-iron core enclosed within the field of the coil.

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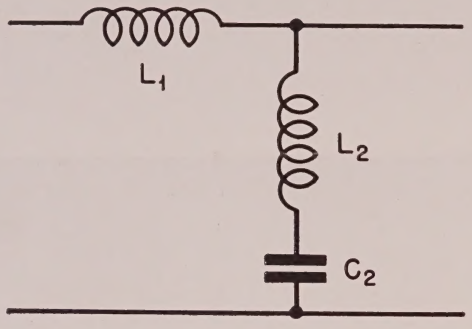
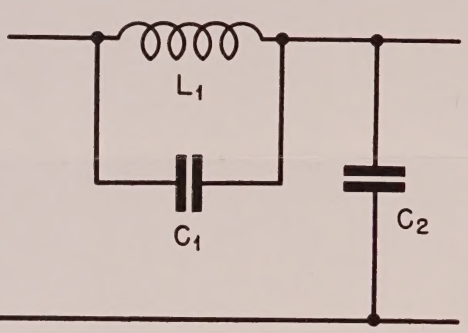
I. LOW-PASS FILTERS

A. SERIES-DERIVED TYPE



B. SHUNT-DERIVED TYPE



LOW-PASS FILTERS

500 Ohms *(m=0.6)*

f	SERIES-DERIVED			SHUNT-DERIVED		
	L_1	L_2	C_2	L_1	C_1	C_2
30	3.186	1.412	12.720	3.186	5.639	12.720
100	0.954	0.4229	3.822	0.954	1.694	3.8220
150	0.636	0.2819	2.544	0.636	1.127	2.544
200	0.4776	0.2117	1.908	0.4776	0.845	1.908
250	0.3822	0.1694	1.530	0.3822	0.678	1.530
300	0.3186	0.1412	1.272	0.3186	0.563	1.272
350	0.2730	0.1210	1.092	0.2730	0.484	1.092
400	0.2388	0.1058	0.954	0.2388	0.422	0.954
450	0.2124	0.0941	0.846	0.2124	0.375	0.846
500	0.1908	0.0845	0.762	0.1908	0.337	0.762
550	0.1734	0.0768	0.696	0.1734	0.308	0.696
600	0.1590	0.0704	0.636	0.1590	0.281	0.636
650	0.1470	0.0651	0.5874	0.1470	0.260	0.5874
700	0.1362	0.0603	0.5454	0.1362	0.241	0.5454
750	0.1272	0.0563	0.5094	0.1272	0.225	0.5094
800	0.1194	0.0529	0.4776	0.1194	0.211	0.4776
850	0.1122	0.0497	0.4494	0.1122	0.199	0.4494
900	0.1062	0.0470	0.4242	0.1062	0.188	0.4242
950	0.1008	0.0446	0.4020	0.1008	0.178	0.4020
1 kc.	0.0954	0.0422	0.3822	0.0954	0.169	0.3822
3 kc.	0.03186	0.01412	0.1272	0.03186	0.0563	0.1272
10 kc.	0.00954	0.00422	0.0382	0.00954	0.0169	0.0382
30 kc.	0.003186	0.00141	0.0127	0.003186	0.00563	0.0127
100 kc.	0.000954	0.000422	0.00382	0.000954	0.00169	0.00382
300 kc.	348.6 μh.	154.5 μh.	0.00127	348.6 μh.	0.000563	0.00127
1 Mc.	95.4 μh.	42.294 μh.	382.2 mmfd.	95.4 μh.	169.4 mmfd.	382.2 mmfd.
3 Mc.	31.86 μh.	14.124 μh.	127.2 mmfd.	31.86 μh.	56.39 mmfd.	127.2 mmfd.
10 Mc.	9.54 μh.	4.229 μh.	38.22 mmfd.	9.54 μh.	16.94 mmfd.	38.22 mmfd.
30 Mc.	3.186 μh.	1.412 μh.	12.72 mmfd.	3.186 μh.	5.63 mmfd.	12.72 mmfd.

I. LOW-PASS FILTERS

A. SERIES-DERIVED TYPE

BASIC FORMULAE	DERIVATIONS FROM K-VALUES
$L_1 = \frac{mR}{\pi f_2}$	$L_1 = mL_{1(K)}$
$L_2 = \frac{(1-m^2)R}{4\pi m f_2}$	$L_2 = \frac{1-m^2}{4m} L_{1(K)}$
$C_2 = \frac{m}{\pi f_2 R}$	$C_2 = mC_{2(K)}$

B. SHUNT-DERIVED TYPE

BASIC FORMULAE	DERIVATIONS FROM K-VALUES
$L_1 = \frac{mR}{\pi f_2}$	$L_1 = mL_{1(K)}$
$C_1 = \frac{1-m^2}{4\pi m f_2 R}$	$C_1 = \frac{1-m^2}{4m} C_{2(K)}$
$C_2 = \frac{m}{\pi f_2 R}$	$C_2 = mC_{2(K)}$

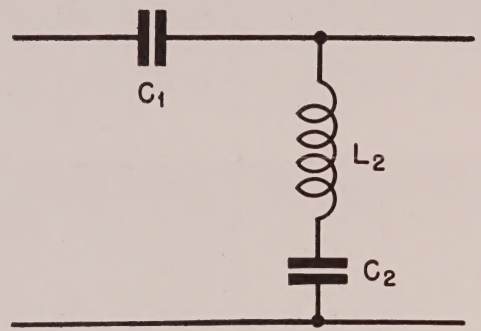
LOW-PASS FILTERS

10,000 Ohms *(m=0.6)*

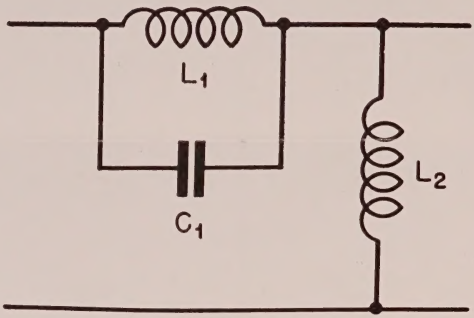
f	SERIES-DERIVED			SHUNT-DERIVED		
	L_1	L_2	C_2	L_1	C_1	C_2
30	63.6	28.19	0.6360	63.6	0.28196	0.6360
100	19.08	8.458	0.1908	19.08	0.08458	0.1908
150	12.72	5.639	0.1272	12.72	0.05639	0.1272
200	9.54	4.229	0.0954	9.54	0.04229	0.0954
250	7.62	3.378	0.0762	7.62	0.03378	0.0762
300	6.36	2.819	0.0636	6.36	0.02819	0.0636
350	5.454	2.417	0.0545	5.454	0.02417	0.0545
400	4.776	2.117	0.0477	4.776	0.02117	0.0477
450	4.242	1.880	0.0424	4.242	0.01880	0.0424
500	3.822	1.694	0.0382	3.822	0.01694	0.0382
550	3.468	1.537	0.0346	3.468	0.01537	0.0346
600	3.186	1.412	0.0318	3.186	0.0142	0.0318
650	2.940	1.303	0.0294	2.940	0.0130	0.0294
700	2.724	1.207	0.0272	2.724	0.0120	0.0272
750	2.544	1.127	0.0254	2.544	0.0112	0.0254
800	2.388	1.058	0.0238	2.388	0.0105	0.0238
850	2.244	0.9948	0.0224	2.244	0.00994	0.0224
900	2.124	0.9416	0.0212	2.124	0.00941	0.0212
950	2.016	0.8937	0.0201	2.016	0.00893	0.0201
1 kc.	1.908	0.8458	0.0190	1.908	0.00845	0.0190
3 kc.	0.636	0.2819	0.00636	0.636	0.002819	0.00636
10 kc.	0.1908	0.08458	0.00190	0.1908	0.0008458	0.00190
30 kc.	0.0636	0.02819	0.000636	0.0636	0.0002819	0.000636
100 kc.	0.01908	0.00845	190.8 mmfd.	0.01908	84.58 mmfd.	190.8 mmfd.
300 kc.	0.00636	0.00281	63.6 mmfd.	0.00636	28.196 mmfd.	63.6 mmfd.
1 Mc.	0.001908	0.000845	19.08 mmfd.	0.001908	8.458 mmfd.	19.08 mmfd.
3 Mc.	0.000636	0.000281	6.36 mmfd.	0.000636	2.819 mmfd.	6.36 mmfd.
10 Mc.	190.8 μh.	84.58 μh.	1.908 mmfd.	190.8 μh.	0.8458 mmfd.	1.908 mmfd.
30 Mc.	63.6 μh.	28.19 μh.	0.636 mmfd.	63.6 μh.	0.2819 mmfd.	0.636 mmfd.

II. HIGH-PASS FILTERS

A. SERIES-DERIVED TYPE



B. SHUNT-DERIVED TYPE



HIGH-PASS FILTERS

500 Ohms *(m=0.6)*

f	SERIES-DERIVED			SHUNT-DERIVED		
	L_2	C_1	C_2	L_1	L_2	C_1
30	22.33	8.85	19.912	4.897	22.33	8.85
100	0.663	2.65	5.962	1.492	0.663	2.65
150	0.441	1.76	3.975	0.993	0.441	1.76
200	0.330	1.32	2.985	0.742	0.330	1.32
250	0.265	1.06	2.388	0.596	0.265	1.06
300	0.221	0.886	1.991	0.498	0.221	0.886
350	0.190	0.755	1.706	0.427	0.190	0.755
400	0.1658	0.663	1.492	0.373	0.1658	0.663
450	0.1473	0.590	1.327	0.331	0.1473	0.590
500	0.1326	0.530	1.192	0.298	0.1326	0.530
550	0.1205	0.481	1.083	0.271	0.1205	0.481
600	0.1105	0.441	0.993	0.248	0.1105	0.441
650	0.1020	0.408	0.918	0.229	0.1020	0.408
700	0.0946	0.378	0.851	0.213	0.0946	0.378
750	0.0885	0.353	0.795	0.199	0.885	0.353
800	0.0825	0.331	0.746	0.186	0.0825	0.331
850	0.0780	0.311	0.701	0.175	0.780	0.311
900	0.0736	0.295	0.663	0.165	0.0736	0.295
950	0.0698	0.280	0.6036	0.1505	0.0698	0.280
1 kc.	0.0633	0.265	0.596	0.0149	0.0663	0.265
3 kc.	0.0223	0.0885	0.1991	0.0498	0.0223	0.0885
10 kc.	0.00663	0.0265	0.0596	0.0149	0.00663	0.0265
30 kc.	0.00223	0.00885	0.01991	0.00498	0.00223	0.00885
100 kc.	663.3 μh.	0.00265	0.00596	1492.5 μh.	663.3 μh.	0.00265
300 kc.	223.3 μh.	885 mmfd.	1991.25 mmfd.	498.75 μh.	223.3 μh.	885 mmfd.
1 Mc.	66.33 μh.	265 mmfd.	596.25 mmfd.	149.25 μh.	66.33 μh.	265 mmfd.
3 Mc.	22.33 μh.	88.5 mmfd.	199.1 mmfd.	49.875 μh.	22.33 μh.	88.5 mmfd.
10 Mc.	6.63 μh.	26.5 mmfd.	59.625 mmfd.	14.92 μh.	6.63 μh.	26.5 mmfd.
30 Mc.	2.23 μh.	8.85 mmfd.	19.91 mmfd.	4.897 μh.	2.23 μh.	8.85 mmfd.

II. HIGH-PASS FILTERS

A. SERIES-DERIVED TYPE

BASIC FORMULAE	DERIVATIONS FROM K-VALUES
$L_2 = \frac{R}{4\pi m f_1}$	$L_2 = \frac{L_{2(K)}}{m}$
$C_1 = \frac{1}{4\pi m f_1 R}$	$C_1 = \frac{C_{1(K)}}{m}$
$C_2 = \frac{m}{(1-m^2) f_1 \pi R}$	$C_2 = \left(\frac{4m}{1-m^2}\right) C_{1(K)}$

B. SHUNT-DERIVED TYPE

BASIC FORMULAE	DERIVATIONS FROM K-VALUES
$L_1 = \frac{mR}{(1-m^2)\pi f_1}$	$L_1 = \left(\frac{4m}{1-m^2}\right) L_{2(K)}$
$C_1 = \frac{1}{4\pi m f_1 R}$	$C_1 = \frac{C_{1(K)}}{m}$
$L_2 = \frac{R}{4\pi m f_1}$	$L_2 = \frac{L_{2(K)}}{m}$

HIGH-PASS FILTERS

10,000 Ohms (m=0.6)

f	SERIES-DERIVED			SHUNT-DERIVED		
	L_2	C_1	C_2	L_1	L_2	C_1
30	44.166	0.4416	0.9937	99.375	44.166	0.4416
100	13.266	0.1326	0.2985	29.850	13.266	0.1326
150	8.850	0.885	0.1991	19.912	8.850	0.885
200	6.633	0.0663	0.1492	14.925	6.633	0.0663
250	5.300	0.0530	0.1192	11.925	5.300	0.0530
300	4.416	0.04411	0.0993	9.937	4.416	0.0441
350	3.800	0.0380	0.0855	8.550	3.80	0.0380
400	3.316	0.0331	0.0746	7.462	3.316	0.0331
450	2.950	0.0295	0.0663	6.637	2.950	0.0295
500	2.650	0.0265	0.0596	5.962	2.650	0.0265
550	2.416	0.0241	0.0543	5.437	2.416	0.0241
600	2.216	0.0221	0.0498	4.987	2.216	0.0221
650	2.033	0.0203	0.0457	4.575	2.033	0.0203
700	1.900	0.0190	0.0427	4.275	1.900	0.0190
750	1.766	0.0176	0.0397	3.975	1.766	0.0176
800	1.655	0.0165	0.0373	3.731	1.655	0.0165
850	1.560	0.0156	0.0351	3.510	1.560	0.0156
900	1.473	0.0147	0.0331	3.315	1.473	0.0147
950	1.395	0.0139	0.0314	3.146	1.395	0.0139
1 kc.	1.326	0.0132	0.0298	2.985	1.326	0.0132
3 kc.	0.4416	0.00441	0.00993	0.9937	0.4416	0.00441
10 kc.	0.1326	132.66 mmfd.	2985 mmfd.	0.2985	0.1326	132.66 mmfd.
30 kc.	0.0441	44.166 mmfd.	993.75 mmfd.	0.0937	0.0441	44.166 mmfd.
100 kc.	0.01326	13.266 mmfd.	298.5 mmfd.	0.0298	0.01326	13.266 mmfd.
300 kc.	0.00441	4.441 mmfd.	99.375 mmfd.	0.00937	0.00441	4.441 mmfd.
1 Mc.	1326.6 μh.	0.1326 mmfd.	2.985 mmfd.	2985.0 μh.	1326.6 μh.	1.326 mmfd.
3 Mc.	441.6 μh.	0.4416 mmfd.	9.937 mmfd.	993.75 μh.	441.6 μh.	0.4416 mmfd.
10 Mc.	132.6 μh.	1.326 mmfd.	29.85 mmfd.	298.5 μh.	132.6 μh.	0.1326 mmfd.
30 Mc.	44.1 μh.	0.0441 mmfd.	0.9937 mmfd.	99.375 μh.	44.1 μh.	0.0441 mmfd.

High Altitude

OIL-FILLED CAPACITORS

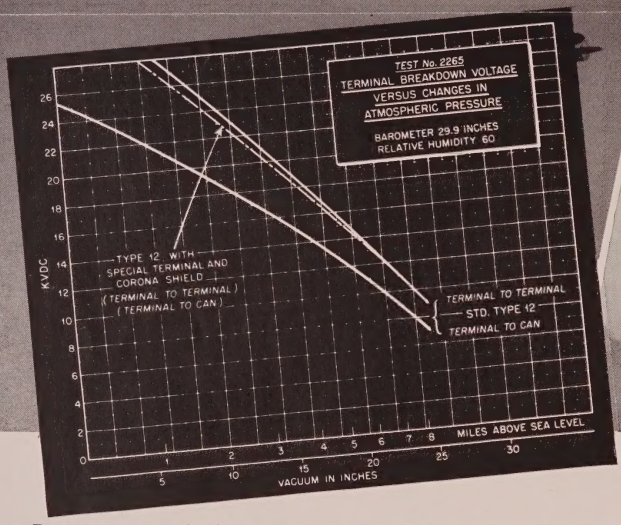


Photo Courtesy of Bell Aircraft Corp., makers of the famous Aircobras.

● Type 12 is a standard Aerovox capacitor. Exclusive Hyvol dielectric oil. Special ceramic insulators on ribbed cap, for ratings up to 7500 v. D.C.W.

At high altitudes encountered in aircraft applications, however, things do happen. While Hyvol maintains the effective capacitance even at sub-zero temperatures found high above the earth, the terminal breakdown voltage drops rapidly in the rarefied atmospheres.

To meet such conditions, Aerovox engineers redesigned the terminals of Type 12. One terminal became a short screw post. The other, a tall ceramic insulator with corona shield at top. Result: minimized surface leakage; minimized corona losses; greatly stepped-up breakdown voltage at high altitudes. The chart tells the story.

Ingenious revisions and adaptations of standard Aerovox types, such as this, are meeting unusual requirements —quickly, fully, economically.

Write for latest Transmitting Capacitor Catalog. And try A.A.E.* on that tough capacitance problem.

*Aerovox Application Engineering

AEROVOX Capacitors

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